SIGMA S6000 IO/P Module

User's Manual

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1 Preface

The SELCO SIGMA S6000 IO/P module provides integrated protection, load shedding and programmable analogue outputs. The S6000 module also includes data acquisition capabilities for all parameters related to the three phased power source. Furthermore the S6000 module works as the interface to the SELCO SIGMA S6100 S/LS module, which adds the functionality of frequency stabilization, voltage stabilization, voltage matching, check/automatic synchronization and active/reactive load sharing. Finally the S6000 provides the basic parameters required by the SELCO SIGMA S6600/S6610 Power Manager.

2 Isolation and Grounding

In marine installations ground and common reference (COM) should not be connected together. In a ship installation the hull is the “ground”. Connecting any of the COM connections on any of the modules within a SIGMA system to ground (hull) or switchboard chassis may cause instability within the system.

One, and only one, COM connection should to be made between SIGMA modules. This is preferably the COM connection of the CAN bus.

The Primary and Backup 24 VDC supplies are isolated from the remaining electronics of the module and therefore also from the common reference (COM). The negative poles of the 24 VDC supplies can be connected to the common reference (COM), provided that the either one, or both supplies serves as references for auxiliary relays driven by SIGMA open collector outputs. In this case the supplies negative poles should not be connected to ground (hull) or switchboard chassis.

As a general rule:

1. COM terminals should not be connected to ground (hull) or switchboard chassis.

2. Negative poles of the primary and back-up supplies should not be connected to ground (hull) or switchboard chassis.

3. Negative poles of the primary and back-up supplies and COM can be connected together, provided that the negative poles of the primary and back-up supplies are not connected to ground (hull) or switchboard chassis.

3 Function

The S6000 module provides integrated protection, load shedding (trip of non-essential loads), analogue outputs and data acquisition for a three phased power source.

3.1 Protection

The S6000 module includes a total of six programmable definite time protection functions. Each one of these six protection functions can be configured with a trip level, a delay and mode of operation. Selected protection functions include two trip levels (low and high). The protection operates on RMS readings sampled over one or four periods (depending on the rated frequency).

Six LED's on the front, one dedicated to each protection function, provides visual information on the status of the integrated protection system. A protection LED will start flashing the moment the trip level of the related protection function is exceeded (to indicate level pick-up). The LED will continue flashing while the delay is counting, provided that the parameter stays within the critical area. The C/B Trip relay trips if the level is exceeded for the full duration of the delay, in which case the protection LED will change to steady light. Otherwise the delay is automatically reset and the LED is turned off.

A dedicated digital output (open collector) is provided for each of the six protection function. Each open collector output can be configured to operate as a pre-alarm for the related protection function. Alternatively the outputs are simply activated when the circuit breaker is tripped (to indicate the cause). The function depends on whether or not the pre-alarm delay has been configured. The LED and output of a triggering protection function will stay active until reset. Reset is done by an external input (C/B RESET) or from the optional S6500, S6600 or S6610 modules.

The main purpose of the S6000 module is to protect the power source by tripping the circuit breaker. The circuit breaker is tripped through the built-in C/B trip relay. The C/B trip relay can be configured for normally de-energized or normally energized operation.

3.1.1 Short Circuit

The short circuit protection function (SC protection) can be enabled or disabled. If enabled, the SC protection will trip the circuit breaker in case a short circuit is detected between any one of the three phases of the power source. The SC protection will always act on the highest of the three currents measured among the three phases.

$$I_1 \quad I_2 \quad I_3$$

The trip level is configured as a percentage according to the generator maximum current (GENMAXCUR) specified in the configuration.

The open collector output is activated after the pre-alarm delay has passed (if configured). The trip signal will be issued if the critical level is exceeded continuously for the duration of the main delay. Both delays are configured in milliseconds.

$$I_1 \cdot I_2 \cdot I_3 \rangle \frac{Level \cdot GENMAXCUR}{100}$$

The SC LED provides local status information, while the SC open collector output can be used for remote signalling.

The short circuit protection works in a similar way to the over current protection. However, the short circuit function operates on higher currents within a shorter time frame.

Please note that most marine classification societies also requires the installation of a discrete isolated short-circuit relay (such as the SELCO T2300). This is to provide perfect and total redundancy on this very important protection function.

3.1.2 Over Current

The over current protection function (OC protection) can be enabled or disabled. If enabled, the OC protection will trip the circuit breaker in case excessive current is detected in any one of the three phases. The OC protection will always act on the highest of the three currents measurements.

$$I_1 \quad I_2 \quad I_3$$

The trip level is configured as a percentage according to the generator maximum current (GENMAXCUR) specified within the system configuration.

The open collector output is activated after the pre-alarm delay has passed (if configured). The trip signal will be issued if the critical level is exceeded continuously for the duration of the main delay. Both delays are configured in seconds.

$$I_1 \; or \; I_2 \; or \; I_3 \rangle \frac{Level \cdot GENMAXCUR}{100}$$

The OC LED provides local status information, while the OC open collector output can be used for remote signalling.

The over current protection works in a similar way to the short circuit protection, however over current operates on lower currents within a longer time frame.

3.1.3 Overload

The overload protection function (OL protection) can be enabled or disabled. If enabled, the OL protection will trip the circuit breaker in case of excessive active current or active load. The configuration determines the mode of operation (active current or active load). However, the active load modes are only available when the S6000 module has connection to neutral and is configured to measure active load as Watt (as opposed to Ampere).

The OL protection can either act on the highest of the three parameters (active current or load in each individual phase) or it can act on the sum of active loads (e.g. the load indicated on the switchboard kW meter).

The open collector output is activated after the pre-alarm delay has passed (if configured). The trip signal will be issued if the critical level is exceeded continuously for the duration of the main delay. Both delays are configured in seconds.

The OL LED provides localized status information, while the OL open collector output can be used for remote signalling.

3.1.3.1 Active Phase Current

The S6000 module will calculate each component of active currents as follows (active current mode).

$$IAct_1 = I_1 \times \cos\varphi \quad IAct_2 = I_2 \times \cos\varphi \quad IAct_3 = I_3 \times \cos\varphi$$

The trip level is defined as a percentage of the generators maximal current (in one phase). Please note that the reference is expressed by the preconfigured power factor.

$$I_{ACT_1}\ or\ I_{ACT_2}\ or\ I_{ACT_3} \rangle \frac{Level \cdot GENMAXCUR}{100}$$

3.1.3.2 Active Phase Load

The components of active loads will be calculated as shown below (active load mode).

$$P_1 = U_{1N} \times I_1 \times \cos\varphi \quad P_2 = U_{2N} \times I_2 \times \cos\varphi \quad P_3 = U_{3N} \times I_3 \times \cos\varphi$$

The trip level is defined as a percentage of the generators phase capacity. Please note that the reference is expressed by the preconfigured power factor.

$$P_1\ or\ P_2\ or\ P_3 \rangle \frac{\left(Level \cdot \left(\frac{NOMVOLT}{\sqrt{3}}\right) \cdot GENMAXCUR \cdot PF\right)}{100}$$

3.1.3.3 Sum Active Load

The sum of active loads will be calculated by the sum of the individual active load components.

$$P = P_1 + P_2 + P_3 = (U_{1N} \times I_1 \times \cos\varphi) + (U_{2N} \times I_2 \times \cos\varphi) + (U_{3N} \times I_3 \times \cos\varphi)$$

The trip level is configured as a percentage according to the generators capacity. Please note that the reference is expressed by the preconfigured power factor.

$$P \rangle \frac{\left(Level \cdot \left(3\left(\frac{NOMVOLT}{\sqrt{3}}\right) \cdot GENMAXCUR \cdot PF\right)\right)}{100}$$

3.1.4 Reverse Power

The reverse power protection function (RP protection) can be enabled or disabled. If enabled, the RP protection will trip the circuit breaker in case of “motoring”, which occurs when current flows into instead of out of the generator. The configuration determines the mode of operation (active current or active load). However, the active load modes are only available when the S6000 module has connection to neutral and is configured to measure active load as Watt (as opposed to Ampere).

The RP protection can either act on the lowest of the three parameters (active current or load in each individual phase) or it can act on the sum of active loads (e.g. the load indicated on the switchboard kW meter).

The open collector output is activated after the pre-alarm delay has passed (if configured). The trip signal will be issued if the critical level is exceeded continuously for the duration of the main delay. Both delays are configured in seconds.

The RP LED provides localized status information, while the RP open collector output can be used for remote signalling.

3.1.4.1 Active Phase Current

The S6000 module will calculate each component of active currents as follows (active current mode).

$$IAct_1 = I_1 \text{ x } \cos\varphi \quad IAct_2 = I_2 \text{ x } \cos\varphi \quad IAct_3 = I_3 \text{ x } \cos\varphi$$

The trip level is defined as a percentage of the generators maximal current (in one phase). Please note that the reference is expressed by the preconfigured power factor.

$$I_{ACT_1} \; or \; I_{ACT_2} \; or \; I_{ACT_3} \rangle \frac{Level \cdot GENMAXCUR \cdot PF}{100}$$

3.1.4.2 Active Phase Load

The components of active loads will be calculated as shown below (active load mode).

$$P_1 = U_{1N} \text{ x } I_1 \text{ x } \cos\varphi \quad P_2 = U_{2N} \text{ x } I_2 \text{ x } \cos\varphi \quad P_3 = U_{3N} \text{ x } I_3 \text{ x } \cos\varphi$$

The trip level is defined as a percentage of the generators phase capacity. Please note that the reference is expressed by the preconfigured power factor.

$$P_1 \; or \; P_2 \; or \; P_3 \rangle \frac{\left(Level \cdot \left(\frac{NOMVOLT}{\sqrt{3}} \right) \cdot GENMAXCUR \cdot PF \right)}{100}$$

3.1.4.3 Sum Active Load

The sum of active loads will be calculated by the sum of the individual active load components.

$$P = P_1 + P_2 + P_3 = (U_{1N} \text{ x } I_1 \text{ x } \cos\varphi) + (U_{2N} \text{ x } I_2 \text{ x } \cos\varphi) + (U_{3N} \text{ x } I_3 \text{ x } \cos\varphi)$$

The trip level is configured as a percentage according to the generators capacity. Please note that the reference is expressed by the preconfigured power factor.

$$P \rangle \frac{\left(Level \cdot \left(3 \left(\frac{NOMVOLT}{\sqrt{3}} \right) \cdot GENMAXCUR \cdot PF \right) \right)}{100}$$

3.1.5 Excitation Loss

The excitation loss protection function (EL protection) can be enabled or disabled. If enabled, the EL protection will trip the circuit breaker in case of reverse reactive current or power, which occurs if the generator looses its excitation. The configuration determines the mode of operation (reactive current or reactive load). However, the reactive load modes are only available when the S6000 module has connection to neutral and is configured to measure reactive load as VAr (as opposed to Ampere).

The EL protection can either act on the lowest of the three parameters (reactive current or load in each individual phase) or it can act on the sum of reactive loads (e.g. the load indicated on the switchboard kVAr meter).

The open collector output is activated after the pre-alarm delay has passed (if configured). The trip signal will be issued if the critical level is passed continuously for the duration of the main delay. Both delays are configured in seconds.

The EL LED provides localized status information, while the EL open collector output can be used for remote signalling.

3.1.5.1 Reactive Phase Current

The S6000 module will calculate each component of reactive currents as follows (reactive current mode).

$$IReact_1 = I_1 \text{ x } \sin\varphi \quad IReact_2 = I_2 \text{ x } \sin\varphi \quad IReact_3 = I_3 \text{ x } \sin\varphi$$

The trip level is defined as a percentage of the generators maximal current (in one phase). Please note that the reference is expressed by the preconfigured power factor.

$$I\,\mathrm{Re}act_1 \text{ or } I\,\mathrm{Re}act_2 \text{ or } I\,\mathrm{Re}act_3 \langle \frac{(Level \cdot GENMAXCUR \cdot SIN(A\cos(PF)))}{100}$$

3.1.5.2 Reactive Phase Load

The components of active loads will be calculated as shown below (active load mode).

$$Q_1 = U_{1N} \text{ x } I_1 \text{ x } \sin\varphi \quad Q_2 = U_{2N} \text{ x } I_2 \text{ x } \sin\varphi \quad Q_3 = U_{3N} \text{ x } I_3 \text{ x } \sin\varphi$$

The trip level is defined as a percentage of the generators phase capacity. Please note that the reference is expressed by the preconfigured power factor.

$$Q_1 \text{ or } Q_2 \text{ or } Q_3 \langle \frac{\left(Level \cdot \left(\frac{NOMVOLT}{\sqrt{3}}\right) \cdot GENMAXCUR \cdot SIN(A\cos(PF))\right)}{100}$$

3.1.5.3 Sum Reactive Load

The sum of reactive loads will be calculated by the sum of the individual active load components.

$$Q = Q_1 + Q_2 + Q_3 = (U_{1N} \text{ x } I_1 \text{ x } \sin\varphi) + (U_{2N} \text{ x } I_2 \text{ x } \sin\varphi) + (U_{3N} \text{ x } I_3 \text{ x } \sin\varphi)$$

The trip level is configured as a percentage according to the generators capacity. Please note that the reference is expressed by the preconfigured power factor.

$$Q \rangle \frac{\left(Level \cdot \left(3\left(\frac{NOMVOLT}{\sqrt{3}}\right) \cdot GENMAXCUR \cdot SIN\left(A\cos\left(PF\right)\right)\right)\right)}{100}$$

3.1.6 Voltage Establishment

The voltage establishment protection function (VE protection) can be enabled or disabled. If enabled the VE protection will trip the circuit breaker in case the phase-phase voltages between any of the three phases becomes either too low or too high. The VE protection will act on the lowest or the highest of the three phase-phase voltage measurements, depending on whether the low or the high level is passed.

$$U_{12} \quad U_{23} \quad U_{31}$$

The trip level is configured as a percentage according to the nominal phase-phase voltage specified within the system configuration.

$$U_{12}\ or\ U_{23}\ or\ U_{31} \langle \frac{Lower\ Level \cdot NOMVOLT}{100}$$

And

$$U_{12}\ or\ U_{23}\ or\ U_{31} \rangle \frac{Upper\ Level \cdot NOMVOLT}{100}$$

The open collector output is activated after the pre-alarm delay has passed (if configured). The trip signal will be issued if the critical level is exceeded continuously for the duration of the main delay. Both delays are configured in seconds.

The VE LED provides localized status information, while the VE open collector output can be used for remote signalling.

3.1.7 Frequency Establishment

The frequency establishment protection function can be enabled or disabled. If enabled the frequency establishment protection will trip the breaker in case the generator frequency becomes either too low or too high. This function is only active when the circuit breaker is closed.

$$f$$

The trip level is configured as a percentage according to the rated frequency specified within the system configuration of the related S6000 module.

$$f \langle \frac{Lower\ Level \cdot RATEFREQ}{100}$$

or

$$f \rangle \frac{Lower\ Level \cdot RATEFREQ}{100}$$

The delay is configured in seconds. Trip will occur only if the low or the high critical level is exceeded continuously for the duration of the delay.

3.2 Load Shedding

The IO/P module includes load shedding (load depending trip of non-essential loads) on two independent levels. The load shedding function can be configured to operate either on low frequency, high load or high current. The two load shedding functions can be configured individually with regard to trip level, delay, relay function and mode of operation.

When in load or current mode, the two load trip functions operate much like definite time protection functions (e.g. the OL protection function).

Two front folio LEDs, one dedicated to each load trip function, provide information on the status of the load shedding system. A load trip LED will start flashing the moment the trip level of the related function is exceeded (to indicate level pick-up). The LED will continue flashing while the parameter remains within the critical area, provided that the delay has not passed. The dedicated relay is tripped and the LED changes to steady light if the parameter stays inside the critical area for the full duration of the delay. Otherwise the delay is reset and the LED is turned off.

A dedicated relay is provided for each of the two load trip functions. The LED of a triggering load trip function will stay active until reset manually. Reset is done by an external signal connected to the NE RESET input.

A dedicated relay is provided for each of the two load trip functions. Each relay can be configured for normally de-energized or normally energized operation. The relays can be configured to latch until reset or to automatically reset by hysteresis (second level for reset).

3.2.1 Non-Essential 1

The first non-essential load trip function (NE1 load trip) can be enabled or disabled. If enabled, the NE1 load trip will trip the NE1 relay in case of low frequency, high active current/load or high current. When configured to trip on load or current, the NE1 load trip can either act on the highest of the three active current or load calculations (each individual phase component) or it can act on the sum of active load, which is typically indicated on the switch board kW meter. The configuration determines the mode of operation. However, the active load mode is only available when the S6000 module has connection to neutral.

The trip level is configured as a percentage according to nominal frequency, the generator maximum current or the power sources active capacity. The power source active capacity is calculated from generator maximum current and the nominal phase-phase voltage located within the system configuration. The delay is configured in seconds. The trip signal will be issued if the trip level is exceeded continuously for the duration of the delay.

The NE1 LED provides localized status information, while the NE1 relay can be used both for load trip and remote signalling.

The NE1 relay can be configured for latching or non-latching operation. Latching operation works with external reset through the NE reset input. In non-latching mode reset is done by use of a hysteresis. The hysteresis will cause the function to auto-reset when the parameter goes above/below then trip level minus the hysteresis.

3.2.1.1 Frequency

The S6000 will calculate the frequency to determine if it is low enough to trip the NE function.

$$f$$

The trip level is defined as a percentage of the generators rated frequency (RATEDFREQ).

$$f \langle \frac{Level \cdot RATEFREQ}{100}$$

3.2.1.2 Active Phase Current

The S6000 module will calculate each component of active currents as follows (active current mode).

$$IAct_1 = I_1 \text{ x Cos } \varphi \quad IAct_2 = I_2 \text{ x Cos } \varphi \quad IAct_3 = I_3 \text{ x Cos } \varphi$$

The trip level is defined as a percentage of the generators maximal current (in one phase). Note that the reference is expressed by the preconfigured power factor.

$$IAct_1 \ or \ IAct_2 \ or \ IAct_3 \rangle \ \frac{(Level \cdot GENMAXCUR \cdot PF)}{100}$$

3.2.1.3 Active Phase Load

The components of active loads will be calculated as shown below (active load mode).

$$P_1 = U_{1N} \text{ x } I_1 \text{ x Cos } \varphi \quad P_2 = U_{2N} \text{ x } I_2 \text{ x Cos } \varphi \quad P_3 = U_{3N} \text{ x } I_3 \text{ x Cos } \varphi$$

The trip level is defined as a percentage of the generators phase capacity. Note that the reference is expressed by the preconfigured power factor.

$$P_1 \ or \ P_2 \ or \ P_3 \rangle \ \frac{\left(Level \cdot \left(\frac{NOMVOLT}{\sqrt{3}}\right) \cdot GENMAXCUR \cdot PF\right)}{100}$$

3.2.1.4 Sum Active Load

The sum of active loads will be calculated by the sum of the individual active load components.

$$P = P_1 + P_2 + P_3 = (U_{1N} \text{ x } I_1 \text{ x Cos } \varphi) + (U_{2N} \text{ x } I_2 \text{ x Cos } \varphi) + (U_{3N} \text{ x } I_3 \text{ x Cos } \varphi)$$

The trip level is configured as a percentage according to the generators capacity. Note that the reference is expressed by the preconfigured power factor.

$$P \rangle \frac{\left(Level \cdot \left(3 \left(\frac{NOMVOLT}{\sqrt{3}} \right) \cdot GENMAXCUR \cdot PF \right) \right)}{100}$$

3.2.1.5 Current

The S6000 module will measure each component of currents as follows (current mode).

$$I_1 \quad I_2 \quad I_3$$

The trip level is defined as a percentage of the generators maximal current (in one phase).

$$I_1 \; or \; I_2 \; or \; I_3 \rangle \frac{(Level \cdot GENMAXCUR)}{100}$$

The trip level is configured as a percentage according to nominal frequency, the generator maximum current or the power sources active capacity. The power source active capacity is calculated from the generator maximum current and the nominal phase-phase voltage located within the system configuration. The delay is configured in seconds. The trip signal will be issued if the trip level is exceeded continuously for the duration of the delay.

The NE1 LED provides localized status information, while the NE1 relay can be used both for load trip and remote signalling.

The NE1 relay can be configured for latching or non-latching operation.

3.2.2 Non-Essential 2

The second non-essential load trip function (NE2 load trip) can be enabled or disabled. If enabled, the NE2 load trip will trip the NE2 relay in case of low frequency, high active current/load or high current. When configured to trip on load or current, the NE2 load trip can either act on the highest of the three active current or load calculations (each individual phase component) or it can act on the sum of active load, which is typically indicated on the switch board kW meter. The configuration determines the mode of operation. However, the active load mode is only available when the S6000 module has connection to neutral.

The trip level is configured as a percentage according to nominal frequency, the generator maximum current or the power sources active capacity. The power source active capacity is calculated from generator maximum current and the nominal phase-phase voltage located within the system configuration. The delay is configured in seconds. The trip signal will be issued if the trip level is exceeded continuously for the duration of the delay.

The NE2 LED provides localized status information, while the NE2 relay can be used both for load trip and remote signalling.

The NE2 relay can be configured for latching or non-latching operation. Latching operation works with external reset through the NE reset input. In non-latching mode reset is done by use of a hysteresis. The hysteresis will cause the function to auto-reset when the parameter goes above/below then trip level minus the hysteresis.

3.2.2.1 Frequency

The S6000 will calculate the frequency to determine if it is low enough to trip the NE function.

$$f$$

The trip level is defined as a percentage of the generators rated frequency.

$$f \langle \frac{Level \cdot RATEFREQ}{100}$$

3.2.2.2 Active Phase Current

The S6000 module will calculate each component of active currents as follows (active current mode).

$$IAct_1 = I_1 \text{ x } \cos\varphi \quad IAct_2 = I_2 \text{ x } \cos\varphi \quad IAct_3 = I_3 \text{ x } \cos\varphi$$

The trip level is defined as a percentage of the generators maximal current (in one phase). Note that the reference is expressed by the preconfigured power factor.

$$IAct_1 \text{ or } IAct_2 \text{ or } IAct_3 \rangle \frac{(Level \cdot GENMAXCUR \cdot PF)}{100}$$

3.2.2.3 Active Phase Load

The components of active loads will be calculated as shown below (active load mode).

$$P_1 = U_{1N} \text{ x } I_1 \text{ x } \cos\varphi \quad P_2 = U_{2N} \text{ x } I_2 \text{ x } \cos\varphi \quad P_3 = U_{3N} \text{ x } I_3 \text{ x } \cos\varphi$$

The trip level is defined as a percentage of the generators phase capacity. Note that the reference is expressed by the preconfigured power factor.

$$P_1 \text{ or } P_2 \text{ or } P_3 \rangle \frac{\left(Level \cdot \left(\frac{NOMVOLT}{\sqrt{3}}\right) \cdot GENMAXCUR \cdot PF\right)}{100}$$

3.2.2.4 Sum Active Load

The sum of active loads will be calculated by the sum of the individual active load components.

$$P = P_1 + P_2 + P_3 = (U_{1N} \text{ x } I_1 \text{ x } \cos\varphi) + (U_{2N} \text{ x } I_2 \text{ x } \cos\varphi) + (U_{3N} \text{ x } I_3 \text{ x } \cos\varphi)$$

The trip level is configured as a percentage according to the generators capacity. Note that the reference is expressed by the preconfigured power factor.

$$P \rangle \frac{\left(Level \cdot \left(3\left(\frac{NOMVOLT}{\sqrt{3}}\right) \cdot GENMAXCUR \cdot PF\right)\right)}{100}$$

3.2.2.5 Current

The S6000 module will measure each component of currents as follows (current mode).

$$I_1 \quad I_2 \quad I_3$$

The trip level is defined as a percentage of the generators maximal current (in one phase).

$$I_1 \; or \; I_2 \; or \; I_3 \rangle \frac{(Level \cdot GENMAXCUR)}{100}$$

The trip level is configured as a percentage according to nominal frequency, the generator maximum current or the power sources active capacity. The power source active capacity is calculated from the generator maximum current and the nominal phase-phase voltage located within the system configuration. The delay is configured in seconds. The trip signal will be issued if the trip level is exceeded continuously for the duration of the delay.

The NE2 LED provides localized status information, while the NE2 relay can be used both for load trip and remote signalling.

The NE2 relay can be configured for latching or non-latching operation.

3.3 Analogue Outputs

The IO/P module includes three analogue outputs for remote signalling. Each output can be configured to provide information on any one of the parameters which are measured and calculated by the S6000 module. This makes it possible to retrieve e.g. the active load or the power factor as an analogue DC voltage or a current signal.

Apart from the desired parameter, it is necessary to configure the required range of the output signal, which is limited by a maximum operating range of the electronic design (the physical output).

The analogue output operates with two sets of minimum/maximum boundaries. One set defines the range of the indicated parameter, while the other set defines the range of the output signal (DC voltage or current).

The function of the minimum ranges can be described by example. The example illustrates a case where the output is configured to signal active power (P) as a DC voltage between -2.000 and +10.000 VDC. The nominal phase-phase voltage is 400.0 VAC and the generator max current is 60.62 A.

The first thing to do is to set the maximum level of the chosen parameter (in this case P). The maximum level of the parameter is set to 100%, which equals the capacity of the generator. Thus 100% will be calculated as follows.

$$P\max = \frac{\left(100 \cdot \left(3 \cdot \left(\frac{NOMVOLT}{\sqrt{3}}\right) \cdot GENMAXCUR\right)\right)}{100}$$

$$P\max = \frac{\left(100 \cdot \left(3 \cdot \left(\frac{400}{\sqrt{3}}\right) \cdot 60.62\right)\right)}{100}$$

$$= 42 \text{ kW}$$

The parameter minimum level of the parameter is set to -2% in order for the output to indicate a small amount of reverse power. Thus the -2% will be calculated as follows.

$$P_{MIX} = \frac{\left(-2 \cdot \left(3 \cdot \left(\left(\frac{NOMVOLT}{\sqrt{3}}\right) \cdot GENMAXCUR\right)\right)\right)}{100}$$

$$= \frac{\left(-2 \cdot \left(3 \cdot \left(\left(\frac{400}{\sqrt{3}}\right) \cdot 60.62\right)\right)\right)}{100}$$

$$= -840 \text{ W}$$

The output is then configured for DC voltage and the minimum and maximum levels are set. Minimum voltage is set to -2.000 VDC and maximum voltage is set to +10.000 VDC.

The result is that the output will provide a voltage of -2.000 VDC at -840 W and +10.000 VDC at 42kW load.

3.4 Data Acquisition

The S6000 module measures the voltage between all three phases of the power source. Phase-neutral voltages can also be measured, provided that the module has connection to neutral. Furthermore the module will measure the current flowing through each of the three phases.

The S6000 module uses these measurements to calculate the remaining parameters which are necessary to protect, control and monitor the operation of the power source.

The measured and calculated parameters can be read from the RS485 serial communication interface. The communication protocol is MODBUS-RTU (a simple request/answer based protocol). The IO/P module operates as a MODBUS slave and provides the information by request from the master (e.g. a PLC or a SCADA system).

4 System Preparation

4.1 CAN Bus Address

The 4-point dip-switch located on the right hand side of the S6000 module is used to set the CAN bus address. The CAN bus address is set as a binary value on 4 ON/OFF switches. Valid CAN bus address are 1 to 15.

The CAN bus address should be set according to the generator reference number, thus the CAN address of an S6000 module and its partner S6100 should be the same.

It is advisable to assign address 1 to the first pair of S6000/S6100 modules, number 2 to the second pair etc. S6500 user interface modules can be set to any address in the range 1 to 15. However, it is typically most practical to set a single S6500 to number 1. S6600 or S6610 Power Manager modules should be configured with address 1.

Each pair of S6000 and S6100 modules must be assigned a unique CAN bus address.

The binary system works on the principle described below.

- Switch 1 represents the decimal value 1
- Switch 2 represents the decimal value 2
- Switch 3 represents the decimal value 4
- Switch 4 represents the decimal value 8

As an example, the address 1 is assigned by setting switch 1 to ON and the remaining switches to OFF. Address 10 is assigned by setting switch 2 and 4 to ON and switch 1 and 3 to OFF. The decimal value corresponds to the sum of the values ON switch values.

5 Installation

The S6000 module is secured to the rear of the switch board using four 4 mm. (3/16”) screws. DIN rail mounting is not advisable due to the weight of the module.

Please ensure that there is enough space around the module so that the plug-in terminals and RS232 connector can be removed and reinserted. The length of the cables should also allow for the easy removal and insertion of the plug-in terminals. Access to the dip-switches located at the lower right hand corner of the unit might also be necessary.

6 Connection

The S6000 module is connected using plug-in terminals. The plug-in terminals provide safe and durable connection without sacrificing ease of installation and servicing.

Wires should be good quality with a reasonable low internal resistance. It is advisable to use colour coding, as this makes trouble shooting and servicing far easier.

Please ensure that all wires are stripped properly and that the screws of the plug-in terminal rest on the copper and not on the insulation. Insufficient wire stripping is a frequent cause for poor connections.

6.1 Power Supply

The electronics of the S6000 module is powered by two individual supplies, the primary and the backup supply. Both the primary and the backup supply operate on a nominal voltage of +24 V DC.

The S6000 module is capable of operating on both or either one of the two supplies. However, an alarm will be raised if the backup supply fails. Furthermore, each supply will tolerate wide variations in the supply voltage, as required by the marine classification societies.

The primary supply occupies terminal 1 and 2 of the *POWER SUPPLY* plug-in connectors, while the backup supply occupies terminal 3 and 4.

Terminal	Description	Signal	Connection
1	PRIMARY SUPPLY +	+24 V DC	Positive terminal of primary supply
2	PRIMARY SUPPLY -	-24 V DC	Negative terminal of primary supply
3	BACKUP SUPPLY +	+24 V DC	Positive terminal of backup supply
4	BACKUP SUPPLY -	- 24 V DC	Negative terminal of backup supply

The primary and backup supplies are isolated from each other and from the remaining electronics of the module. This means that the supply reference terminals (terminal 2 and 4) have no connection to the modules COM terminals.

The primary and backup supply is designed to cope with relative large voltage fluctuations, as required by the marine classification societies. However, please note that some marine classification societies require that the S6000 module is powered by the generators voltage. This is easily done through adding an auxiliary +24 V DC supply powered by the generator voltage. Please make sure that the auxiliary supply is able to cope with the power demand.

6.1.1 Primary Supply

The switch board +24 V DC power supply system is typically used as the source of the primary supply.

The front folio Primary Supply LED illuminates with a steady green light to indicate that the supply voltage is OK and within the limits of safe operation. A failure of the primary supply will cause the Primary Supply LED to turn off (after a brief delay).

6.1.2 Backup Supply

The engine starter battery or the switch board +24 V DC backup power supply system is typically used as the source of the backup supply.

The front folio Backup Supply LED illuminates with a steady green light to indicate that the supply voltage is OK and within the limits of safe operation. A failure of the backup supply will cause the Backup Supply LED to turn off (after a brief delay) and the ALARM relay to de-energize.

6.2 Voltage Inputs

The AC voltages connect to the *VOLTAGE INPUTS* plug-in terminal. The S6000 module supports both 3-wire and 4-wire power sources. Triangle coupled alternators without neutral are considered 3-wire sources, while star coupled alternators with neutral are considered 4-wire sources. As an example; land based generators are typically equipped with the 4-wire alternators, while marine based generators typically use 3-wire alternators.

The voltage inputs can operate with high voltage (up to 690 VAC nominal), so precaution must be taken to avoid electrical shock and personal injury. Do not touch the *VOLTAGE INPUTS* plug-in terminal unless you are absolutely sure that power source is off (e.g. the generator is stopped and blocked against starting).

Voltages above 690 VAC are supported through use of external transformers (PT's). When using PT's it is important to ensure that the PT's do not affect the phase of the voltage measurement. Phase shift in the PT's will directly affect the calculation of the power factor, and thereby the calculation of active and reactive current/load.

The S6000 measures the individual phase-phase voltage between phases L1 and L2, L2 and L3 and L3 and L1. Phase-neutral voltages are also measured on 4-wire sources, while on 3-wire sources the phase-neutral voltages are estimated based on the assumption that loads are distributed equally among the three phases.

Terminal	Description	Signal	Connection
L1	VOLTAGE INPUTS L1	AC voltage	Generator phase L1
L2	VOLTAGE INPUTS L2	AC voltage	Generator phase L2
L3	VOLTAGE INPUTS L3	AC voltage	Generator phase L3
N	VOLTAGE INPUTS N	Neutral	Generator Neutral (optional)

The three phases of the source L1, L2 and L3 should be connected to L1, L2 and L3 of the *VOLTAGE INPUTS* plug-in terminal. Intermediate 2 A slow-blow fuses should be inserted between the individual phases and the related voltage inputs. It is very important that the phases are connected in the correct order. Interchanging the phases will result in an incorrect power factor calculation and thereby incorrect calculation of active/reactive current/load. It is very import that the three phases are connected to the corresponding terminals (phase 1 to L1, phase 2 to L2 and phase 3 to L3).

Connection of the neutral terminal (terminal N) is optional. The neutral terminal (terminal N) is isolated from the remaining electronics of the module. This means that the neutral terminal have no connection to the modules COM terminals. The neutral terminal does have connection to terminal 1, 3 and 5 of the *CT INPUTS* plug-in terminal.

The VOLTAGE OK LED shows whether or not the voltage levels measured between each of the three phases are within limits. The reference is the nominal phase-phase voltage (NOMVOLT). The voltage levels are compared to the limits defined by the voltage OK window (VOLTOKWND) of the configuration.

The PHASE OK LED will ignite (steady green light) to indicate that the phase sequence is correct. However, the S6000 module is not able to verify that the each phase is connected to the correct terminal. The S6000 module cannot detect the difference between L1-L2-L3, L3-L1-L2 and L2-L3-L1. The S6000 module can only verify that 120 degrees displacement exist between the three phases. The PHASE OK LED requires a "reasonable" level of voltage to become operational.

The best way to ensure correct connection is to follow the wire all the way from the phase copper rail to the specific terminal within the *VOLTAGE INPUTS* plug-in connector.

6.3 Current Inputs

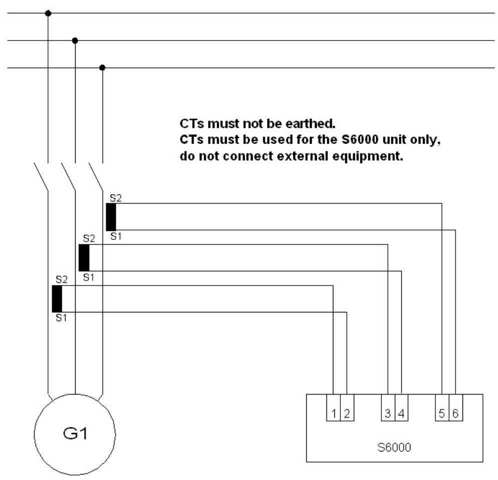
The S6000 module measures current through external current transformers (CT's). The current through each of the three phases (L1, L2 and L3) is measured independently using a separate CT for each phase.

The S6000 module is available in two different variants; one is for 5 A CT's and one for 1 A CT's. Please ensure that you have the correct variant of the module before proceeding with the installation.

The CT ratio should cover maximum current of the generator. E.g. a 400A/5A CT can be used for a 42 kVA/400 VAC generator, provided that the primary wire is looped through the CT 4 times. This adapts the CT to 100A/5A, which covers the generators maximum current of 60.6 A. The CT's must also be capable of coping with short-circuit currents over short periods.

The three external CT's are connected to the *CT INPUTS* plug-in terminal. It is important to ensure that the direction of the current flow is correct. The current flow is indicated by the S1 and S2 notation on the CT. S1 of the CT's connects to terminal 2, 4 and 6 respectively.

CONNECTION OF CURRENT TRANSFORMERS TO SIGMA



Both wires of each CT must be connected to the corresponding CT inputs (S1 and S2) on the S6000 module. External interconnection of the CT's should be avoided. Grounding of the CT wires is not permitted, as this could disturb the measurements in case of an earth fault. Thus, the connection is as follows:

Terminal	Description	Signal	Connection
1	CT INPUTS 1	AC current	S2 of the CT on phase L1
2	CT INPUTS 2	AC current	S1 of the CT on phase L1
3	CT INPUTS 3	AC current	S2 of the CT on phase L2
4	CT INPUTS 4	AC current	S1 of the CT on phase L2
5	CT INPUTS 5	AC current	S2 of the CT on phase L3
6	CT INPUTS 6	AC current	S1 of the CT on phase L3

Make sure that the secondary side of the CT's is shorted (make a connection between S1 and S2) before disconnection of the *CT INPUTS* plug-in connector. Failure to do so may cause damage to the CT's.

One side of the CT's (terminals 1, 3 and 5) are connected to a common point inside the S6000 module (terminal N of the *VOLTAGE INPUTS*). This means other equipment utilizing a similar scheme (common connection of one side of the CT's) cannot share CT's with the S6000 module. Equipment that does not disturb the "loop" of the CT's (e.g. like the SELCO T-Line units) can share the CT's with the S6000 module.

Please note that incorrect connection of the current transformers could result in zero current readings, even when the generator is on load.

Correct measurement of the currents is extremely important, as the SIGMA system relies upon the current measurements for the calculation of power factors, active currents/loads, reactive currents/loads etc. The integrated protection functions and the load sharing functions of the S6100 modules also rely upon the current measurements.

6.4 Sync

The *SYNC* plug-in terminal provides a synchronization signal for the partner S6100 module (if installed).

The synchronization signal is used by the S6100 module (if installed) to determine the zero crossing of the alternator voltage AC curves. This time critical information is required by the S6100 module in order for it to do automatic synchronization. The CAN bus backbone is not fast enough for this purpose.

The synchronization signal is based on dedicated non-isolated RS485 interface. Thus, wiring must be done according to standard RS485 requirements.

Terminal	Description	Signal	Connection
1	SYNC A	RS485 A	Terminal 1 of the partner S6100 SYNC
2	SYNC B	RS485 B	Terminal 2 of the partner S6100 SYNC
3	COM	COM	Terminal 3 of the partner S6100 SYNC

The wires from terminal 1 and 2 should be twisted. A 150 ohm termination resistor must be placed between terminal 1 and 2 (directly at the plug-in terminal) to prevent signal reflections. Terminal 1 must be connected to terminal 1 of the *SYNC* terminal on the partner S6100 module. Likewise terminal 2 must be connected to terminal 2 of the *SYNC* terminal on the partner S6100 module. Lastly, terminal 3 must be connected between the *SYNC* terminals of both modules. Terminal 3 will also serve as the common COM connection between the S6000 and the S6100 module.

6.5 I/O

The *I/O* plug-in connector houses the signals *CB STATE* and the *NE RESET* inputs. Both inputs works with negative reference, meaning the inputs are considered active when at COM level and inactive when left open (disconnected).

Terminal	Description	Signal	Connection
1	C/B STATE	NO contact to COM	External switch, output or relay
2	NE RESET	NO contact to COM	External switch, output or relay

6.5.1 C/B State

The *C/B STATE* input provides feedback from the generator circuit breaker and is used by the S6000 module to determine if the breaker is open or closed. *C/B STATE* is typically connected to COM through an auxiliary contact on the breaker. The breaker is considered closed by the S6000 module when the *C/B STATE* input is at COM level.

6.5.2 NE Reset

The *NE RESET* input is used for manual reset of the two Non-Essential load trip functions. The *NE RESET* input is activated by connection to COM level. Note that the Non-Essential load trip function can also be configured from automatic reset (by hysteresis).

6.6 C/B

The terminals of the relay intended for tripping the circuit breaker (e.g. by the protection functions) is on the *C/B* plug-in connector. The built-in C/B trip relay has two contact sets and is normally energized by default. Note that the C/B trip relay can be reconfigured to be normally energized operation.

Terminal	Description	Signal	Connection
1	C/B TRIP 1	Relay de-energized position	Breaker remote trip
2	C/B TRIP 2	Relay contact	Signal source
3	C/B TRIP 3	Relay energized position	Breaker remote trip

The C/B trip relay connects to the remote trip control input of the generator circuit breaker. Terminal 1 and 3 is typically not connected at the same time. Only one of this signals are taken to the breaker, depending on whether the C/B trip relay is configured for normally energized or de-energized operation.

6.7 Relay Contacts

The *RELAY CONTACTS* plug-in connector includes the terminals for three built-in relays. The first to relays (NE1 and NE2) are intended for trip of non-essential (less important) loads. The last relay is the general alarm relay that will de-energize on system faults.

Terminal	Description	Signal	Connection
1	NE1 1	Relay de-energized position	NE1 remote trip
2	NE1 2	Relay contact	Signal source
3	NE1 3	Relay energized position	NE1 remote trip
4	NE2 1	Relay de-energized position	NE2 remote trip
5	NE2 2	Relay contact	Signal source
6	NE2 3	Relay energized position	NE2 remote trip
7	ALARM 1	Relay de-energized position	ALARM signal
8	ALARM 2	Relay contact	Signal source
9	ALARM 3	Relay energized position	All OK signal

6.7.1 NE1

The NE1 relay has two contact sets and the relay is by default configured for normally de-energized operation. The NE1 relay can be reconfigured for normally energized operation.

6.7.2 NE2

The NE2 relay has two contact sets and the relay is by default configured for normally de-energized operation. The NE2 relay can be reconfigured for normally energized operation.

6.7.3 Alarm

The ALARM includes two contact sets. The alarm relays can only operate as a normally energized relay. This is to ensure that the ALARM relay will trip in case both supplies fail.

6.8 Analogue Outputs

Three analogue outputs are provided on-board of the S6000 module. The analogue outputs are intended for use with third party meters or measuring equipment. Each of the three outputs can be individually configured to provide a DC voltage or current signal in relation to any one of the measured or calculated parameters provided by the S6000 module.

Each analogue output can be configured to provide a DC voltage within the range of -10 to +10 V DC, or a DC current within the range of 0 to 20 mA. All three outputs are isolated from each other and from the remaining electronics of the module. This means that the references of the outputs have no connection to each other or to the common reference (COM) of the module.

The analogue outputs can be used for external indication on meters or to provide analogue readings to e.g. a PLC.

Terminal	Description	Signal	Connection
1	ANALOG OUTPUT 1 VDC	DC voltage	External voltage input
2	ANALOG OUTPUT 1 mA	DC current	External current input
3	ANALOG OUTPUT 1 REF	Reference (isolated)	External reference
4	ANALOG OUTPUT 2 VDC	DC voltage	External voltage input

5	ANALOG OUTPUT 2 mA	DC current	External current input
6	ANALOG OUTPUT 2 REF	Reference (isolated)	External reference
7	ANALOG OUTPUT 3 VDC	DC voltage	External voltage input
8	ANALOG OUTPUT 3 mA	DC current	External current input
9	ANALOG OUTPUT 3 REF	Reference (isolated)	External reference

It is important to note that each analogue output is protected against short-circuit by an internal 10 kOhm resistor. The resistor is placed in series on the output terminal. The output resistor might affect the magnitude of the output signal if the internal resistance of the driven equipment is low. The principle of voltage division applies between the output resistor and the internal resistance of the driven equipment. Example: equipment with an internal resistance of only 10 kOhm would reduce a +10 V DC output voltage to +5 VDC. The two 10 kOhm resistors in series would make up a 1:2 voltage divider.

6.9 C/B Trip Cause & COM

The S6000 module includes six open collector outputs for indication of protection functions or . An open collector output works as an electronic contact to COM.

It is possible to assign any protection function to any of these outputs (see under configuration).

The *C/B Trip Cause & COM* plug-in terminal also houses a COM terminal and the external circuit breaker reset input (C/B Reset).

Terminal	Description	Signal	Connection
1	PROTECTION OUTPUT 1	Open collector output	External input
2	PROTECTION OUTPUT 2	Open collector output	External input
3	PROTECTION OUTPUT 3	Open collector output	External input
4	PROTECTION OUTPUT 4	Open collector output	External input
5	PROTECTION OUTPUT 5	Open collector output	External input
6	PROTECTION OUTPUT 6	Open collector output	External input
7	COM	Common reference	External reference
8	C/B RESET	Open collector output	External input

A trip cause output will become active when the breaker is tripped (through operation of the C/B trip relay. A trip cause output will stay active until a protection reset is issued.

The protection outputs can be programmed to following functions: short-circuit, over-current, over-load, reverse power, excitation loss, over-voltage, under-voltage, over-frequency, under-frequency and frequency deviation alarm (rate of change of frequency).

6.9.1 Short-Circuit

When configured for indication of short-circuit, the open collector output will become active when the short-circuit protection function trips the circuit breaker. The output will stay active until a protection reset is issued.

6.9.2 Over Current

When configured for indication of over current, the open collector output will become active when the over current protection function trips the circuit breaker. The output will stay active until a protection reset is issued.

6.9.3 Overload

When configured for indication of overload, the open collector output will become active when the overload protection function trips the circuit breaker. The output will stay active until a protection reset is issued.

6.9.4 Reverse Power

When configured for indication of reverse power, the open collector output will become active when the reverse power protection function trips the circuit breaker. The output will stay active until a protection reset is issued.

6.9.5 Excitation Loss

When configured for indication of excitation loss, the open collector output will become active when the excitation loss protection function trips the circuit breaker. The output will stay active until a protection reset is issued.

6.9.6 Generator over-voltage

When configured for indication of generator over-voltage, the open collector output will become active when the generator over-voltage protection function trips the circuit breaker. The output will stay active until a protection reset is issued.

6.9.7 Generator under-voltage

When configured for indication of generator under-voltage, the open collector output will become active when the generator under-voltage protection function trips the circuit breaker. The output will stay active until a protection reset is issued.

6.9.8 Generator over-frequency

When configured for indication of generator over-frequency, the open collector output will become active when the generator over-frequency protection function trips the circuit breaker. The output will stay active until a protection reset is issued.

6.9.9 Generator under- frequency

When configured for indication of generator under- frequency, the open collector output will become active when the generator under- frequency protection function trips the circuit breaker. The output will stay active until a protection reset is issued.

6.9.10 Bus bar over-voltage

When configured for indication of bus bar over-voltage, the open collector output will become active when the bus bar over-voltage protection function trips the circuit breaker. The output will stay active until a protection reset is issued.

6.9.11 Bus bar under-voltage

When configured for indication of bus bar under-voltage, the open collector output will become active when the bus bar under-voltage protection function trips the circuit breaker. The output will stay active until a protection reset is issued.

6.9.12 Bus bar over-frequency

When configured for indication of bus bar over-frequency, the open collector output will become active when the bus bar over-frequency protection function trips the circuit breaker. The output will stay active until a protection reset is issued.

6.9.13 Bus bar under- frequency

When configured for indication of bus bar under- frequency, the open collector output will become active when the bus bar under- frequency protection function trips the circuit breaker. The output will stay active until a protection reset is issued.

6.9.14 Frequency deviation (rate of change of frequency ROCOF)

When configured for indication of frequency deviation protection, the open collector output will become active when the frequency deviation protection function trips the circuit breaker. The output will stay active until a protection reset is issued.

6.9.15 COM

The COM terminal is the common reference of the S6000 module. The various digital inputs and the open collector outputs use the COM terminal as reference. The COM terminal has connection to the COM terminal of the *SYNC* plug-in connector.

6.9.16 C/B Reset

The C/B reset input can be used to issue an external reset signal to the S6000 module. C/B reset will reset the C/B trip relay and all active protection causes, provided that none of the protection levels are exceeded.

6.10 RS485

The S6000 module includes an isolated RS485 interface.

Terminal	Description	Signal	Connection
1	REF	Reference (isolated)	Reference of the RS485 bus
2	A	RS485 A	A signal of the RS485 bus
3	B	RS485 B	B signal of the RS485 bus

It is important to note that the RS485 reference is isolated from the common COM of the module.

The 3-wires RS485 bus is connected from module to module.

A termination resistor of 150 ohm must be connected between terminal 2 and 3 at each end of the RS485 bus, preferably directly on the RS485 bus plug-in connector of the first RS485 slave and on the master.

The maximum cable length is 1000 meters. The cable type should be 0.25 - 0.34 mm^2 (AWG23/AWG22). Wires for A and B must be twisted (twisted-pair).

6.11 CAN Bus

The CAN bus is the backbone of the SIGMA system. The CAN bus carries all the measured and calculated parameters between the modules.

Terminal	Description	Signal	Connection
1	COM	Common reference	Reference of the CAN bus
2	CAN L	CAN Lo (data)	CAN Lo signal of the CAN bus
3	-	-	-
4	CAN H	CAN Hi (data)	CAN Hi signal of the CAN bus
5	-	-	-

Terminals 3 and 5 are not used.

The CAN L, CAN H and COM wires starts at one end of the total network, a termination resistor of 124 Ohm is connected between CAN L and CAN H, preferably directly on the CAN bus plug-in connector. The cable is connected form SIGMA module to SIGMA module, without T connections. On the other end of the cable again a 124 Ohm terminator resistor is connected between the CAN lines.

The maximum cable length is 40 meters. The cable type should be 0.25 - 0.34 mm^2 (AWG23/AWG22). Wires for CAN Lo and CAN Hi must be twisted (twisted-pair). The cable should be shielded. The shield must only be connected to chassis/ground at one end.

Every SIGMA module of the installation must be connected to the same CAN bus network. Third party CAN nodes may not be connected to the SIGMA CAN bus.

6.12 Auxiliary I/O

The auxiliary I/O plug-in connector houses general purpose I/O signals.

Terminal	Description	Signal	Connection
1	VOLT / PHASE OK	Open collector output	External input
2	UNLOAD TRIP	Open collector output	External input
3	-	-	-
4	-	-	-
5	-	-	-
6	ABNORMAL TRIP	NO contact to COM	External protection trip
7	COM	Common reference	External reference

6.12.1 Volt / Phase OK

The Volt / Phase OK signal is activated when the VOLTAGE OK and PHASE OK LED’s are a light. The signal indicates that the generators voltage is within limits and that the phase sequence is OK.

6.12.2 Unload Trip

In factory default configuration both, protection trip of the circuit breaker and unload trip are conducted through the C/B trip relay of the S6000. However in case it is necessary to use separate outputs for unload trip and protection trip, the unload trip can be redirected to this open collector output (see under Configuration).

6.12.3 Abnormal Trip

In case this input is activated (connected to COM) a trip signal will be send to the C/B from the C/B trip relay. An abnormal trip will be treated by the Power Management like any other protection trip. Therefore the C/B will be blocked for re-closure until the fault is reset.
The main purpose of this terminal is to implement external protection equipment (like the internal protection functions of the C/B) into the Power Management. In case such external protection equipment is used for the protection of the generator, a feedback from this protection equipment must be connected to this terminal.

7 Configuration

The S6000 module can be configured in three different ways. This section describes the configuration by RS232, as this method of configuration does not require the use of additional modules (the S6500 or S6600).

The S6000 module is delivered with a default configuration.

7.1 Console Password

By default the RS232 console will operate in read only mode. The console can be switched to read/write mode by the enable command.

ENABLE

Enable mode will prompt for a pin code. The default pin code is 0000.

The console can be switched back to read only mode by the disable command.

DISABLE

Please note that the RS232 console pin code is separate for each module. Also, the RS232 pin code is independent from the menu pin code of the UI or PM module.

7.2 Power Source

The first thing to do is to configure the S6000 module to fit the power source.

7.2.1 Voltage

The S6000 module must know then nominal voltage of the power source as well as the primary voltage. The nominal voltage is the nominal voltage that will be present on the *VOLTAGE INPUTS* plug-in connector of the module (actual voltage between L1-L2, L2-L3 and L3-L1 terminals). Please note that all voltage settings are phase-phase voltages.

The nominal voltage is set by the following command. The resolution of the nominal voltage is 100 mV AC.

WRITE SYS NOMVOLT <nominal voltage>

On a system equipped with an S6100 the alternator voltage will change when the nominal voltage is altered, provided that voltage stabilisation is active.

The actual voltage might not be the same as the nominal voltage. The actual voltage could be far higher (e.g. in medium voltage installations), in which case the power source primary voltage is transformed down my external PT's (voltage transformers). It is however typically preferred to do calculations and indication using the true primary voltage.

The primary phase-phase voltage is set by the following command. The resolution is 1 V AC.

WRITE SYS PRIMVOLT <primary voltage>

The primary voltage should be set to the same value as the nominal voltage when no intermediate PT's are used.

The voltage settings will affect the indication of phase-phase and phase-neutral voltages, as well as all parameters based on voltage (e.g. active/reactive loads, VA, generator capacity etc.). The nominal voltage is used for reference by the voltage stabilisation function of the partner S6100 module (if installed).

7.2.2 Generator Maximum Current

The S6000 must be able to determine the capacity of the power source. The capacity is calculated through use of the primary voltage and the maximum current in one phase.

The maximum current of the power source can be calculated based on the following formula. The formula is based on the kVA og kW rating and the primary phase-phase voltage.

$$GENCAP = 3 \cdot \left(\left(\frac{PRIMVOLT}{\sqrt{3}} \right) \cdot GENMAXCUR \cdot Cos\varphi \right)$$

$$GENMAXCUR = \frac{GENCAP}{3 \cdot \left(\left(\frac{PRIMVOLT}{\sqrt{3}} \right) \cdot \cos\varphi \right)}$$

The default settings are done using a power source of 42 kVA with a primary phase-phase voltage of 400 V AC. In this case the power factor (PF) is set to 1.00. Thus the calculations would be as follows.

$$GENMAXCUR = \frac{GENCAP}{3 \cdot \left(\left(\frac{PRIMVOLT}{\sqrt{3}} \right) \cdot \cos\varphi \right)}$$

$$GENMAXCUR = \frac{42000}{3 \cdot \left(\left(\frac{400}{\sqrt{3}} \right) \cdot 1.00 \right)} = 60.6A$$

The example above illustrates that the maximum current in one phase (at full load at PF = 1.00) is 60.6 A. The generator maximum current could also have been derived form the generators kW rating (33.6 kW at PF = 0.8).

Another example is a generator defined by a capacity of 3 x 130 kW at PF = 0.8.

$$GENMAXCUR = \frac{130000}{3 \cdot \left(\left(\frac{400}{\sqrt{3}} \right) \cdot 0.8 \right)} = 234.54A$$

The maximum current is set by the following command. The resolution is 100 mA.

WRITE SYS GENMAXCUR <generator maximum current>

The maximum current is used as 100% references for short-circuit and over current protection. The parameter is also used to calculate 100% references for load (active and reactive) function, as well as the maximum capacity of the power source.

7.2.3 CT Primary Current

The S6000 module conducts its current measurements through external current transformers (CT's). Two different versions of the S6000 module is available, one for 5 A secondary current and one for 1 A secondary current.

It is a requirement that the secondary rated current of the CT's is either 5 A or 1 A. However the primary current depends on the choice of the designer. In order to convert the measured secondary current to primary current, the S6000 module must know the primary rated current.

The CT primary rated current is set by the following command. The resolution is 100 mA.

WRITE SYS CTPRIMCUR <CT primary rated current>

The CT primary current is simply used to scale the measured current to the actual current.

7.2.4 Rated Frequency

The rated frequency must be set in order for the S6000 module to know the 100% reference for the frequency dependent trip functions (e.g. for trip of Non-Essential loads).

The rated frequency is set by the following command. The resolution is 0.1 Hz.

WRITE SYS RATEDFREQ <Rated frequency>

On a system equipped with the S6100 the generator speed will change when the rated frequency is altered, provided that frequency stabilisation is active.

7.2.5 Neutral Connection

The S6000 module must be informed whether or not it has a fixed connection to neutral. The S6000 can only measure the exact phase-neutral voltages if the N-terminal of the *VOLTAGE INPUTS* plug-in connector has connection to neutral. Without neutral connection, phase-neutral voltages are estimated - based on the assumption that the loads are balanced among the three phases.

Neutral connection is only possible on star-coupled generators, which are typically used in land application. Triangle couple generators, which are typically used in marine application, do not provide a neutral connection.

Whether or not the S6000 module has connection to neutral is set by the following command. The choice can be YES or NO.

WRITE SYS NEUTRAL <Choice>

The existence of a neutral connection will affect the way that the S6000 calculates active and reactive loads.

7.2.6 Load Calculation

The S6000 module can operate with or without connection to neutral (e.g. with star or triangle coupled generators). The existence of a neutral connection will determine how the S6000 module can calculate active and reactive load.

The calculation of active and reactive power (expressed in Watt and VAr) in each individual phase, depends upon exact phase-neutral voltage measurements on all three phases. Exact measurement of phase-neutral voltages requires a fixed connection to neutral. Assumptions that phase-phase voltage equals phase-neutral voltage multiplied by the square root of three, requires that the load distribution among the three phases are perfectly balanced. SELCO has chosen not to make this assumption.

With neutral connection (e.g. start coupled generators), the S6000 can calculate active/reactive loads as either active/reactive currents or active/reactive loads (measured in Ampere or Watt/VAr). Without neutral (e.g. triangle coupled generators) loads can only be calculated as active/reactive currents. The setup of the load calculation depends on the setup of the neutral connection.

The load calculation mode is configured by the following command. The choice can be either CUR or LOAD.

WRITE SYS LOADCALC <Choice>

Again, note that the LOAD choice is only valid when WRITE SYS NEUTRAL is set to YES.

7.2.7 Power Factor

The power factor is used for calculation of the 100% references for the various protection and NE trip functions. The typical power factor is 0.8. The range is 0.0 to 1.0.

The power factor is configured by the following command. The resolution is 0.1.

WRITE SYS COSPHI <Power Factor>

7.3 Voltage OK Window

The S6000 module needs to verify whether or not the generator voltage is OK - that is whether or not the voltage level on each of the three phase-phase voltages are within limits.

The voltage window defines the boundaries around (+/-) the nominal voltages which the module regards are acceptable for safe operation. The VOLTAGE OK LED will be lit provided that all three phase-phase voltage measurements are within the limits defined by the voltage window.

The voltage window is configured by the following command. The resolution is 1 %.

WRITE SYS VOLTOKWND <Voltage Window>

7.4 Protection

The protection functions are typically set up by a set point (trip level) and a delay. The trip level is expressed in percent, so it is important to understand how the 100% reference is calculated. This is described in the function section of this manual.

Each one of the protection functions can be enabled or disabled as desired. The parameters of a given protection function has no influence on the system if the function is disabled.

7.4.1 Short-Circuit

The short-circuit protection function can be enabled or disabled by the following command. The choice can be either YES or NO.

WRITE PROTECT SC ENABLED <Choice>

The trip level of the short-circuit protection function is expressed as a percentage according to the generators maximum current (GENMAXCUR) in a single phase. The trip level is set by the following command. The level can be set between 100 and 400 %. Resolution is 1%.

WRITE PROTECT SC LEVEL <Level>

The delay is expressed in milliseconds and can be set between 100 and 1000 ms. Resolution is 1 ms.

WRITE PROTECT SC DELAY <Delay>

The pre-alarm delay is expressed in milliseconds and can be set between 100 and 1000 ms. Resolution is 1 ms.

WRITE PROTECT SC PDELAY <Delay>

7.4.2 Over Current

The over current protection function can be enabled or disabled by the following command. The choice can be either YES or NO.

WRITE PROTECT OC ENABLED <Choice>

The trip level of the over current function is expressed as a percentage according to the generators maximum current (GENMAXCUR) in a single phase. The trip level is set by the following command. The level can be set between 50 and 140 %. Resolution is 1 %.

WRITE PROTECT OC LEVEL <Level>

The delay is expressed in seconds and can be set between 0.1 and 30.0 s. Resolution is 100 ms.

WRITE PROTECT OC DELAY <Delay>

The pre-alarm delay is expressed in seconds and can be set between 0.1 and 30.0 s. Resolution is 100 ms.

WRITE PROTECT OC PDELAY <Delay>

7.4.3 Overload

The overload protection function can be enabled or disabled by the following command. The choice can be either YES or NO.

WRITE PROTECT OL ENABLED <Choice>

The trip level of the overload function is expressed in one of three different ways. The mode of operation depends on the previously explained load calculation parameter and the mode set by the function mode parameter (single phase or sum).

1. According to the generators maximum active current in a single phase. The 100 % reference is the generators maximum current in one phase (GENMAXCUR).

2. According to the generators maximum active load on one phase. The 100 % reference is the primary phase-neutral voltage multiplied by the generators maximum current

$$\frac{PRIMVOLT}{\sqrt{3}} \cdot GENMAXCUR \text{ in one phase.}$$

3. According to the generator sum load (as indicated on the kW meter). The 100 % reference is the sum of the nominal phase-neutral voltages multiplied by the generators maximum current.

$$\frac{PRIMVOLT}{\sqrt{3}} \cdot GENMAXCUR$$

The level is set by the following command. The level can be set between 15 and 150 %. Resolution is 1 %.

WRITE PROTECT OL LEVEL <Level>

The delay is expressed in seconds and can be set between 2.0 and 20.0 s. Resolution is 100 ms.

WRITE PROTECT OL DELAY <Delay>

The pre-alarm delay is expressed in seconds and can be set between 2.0 and 20.0 s. Resolution is 100 ms.

WRITE PROTECT OL PDELAY <Delay>

The mode (single phase or sum) can be set by the following command. The choice can be PHASE or SUM.

WRITE PROTECT OL MODE <Choice>

7.4.4 Reverse Power

The reverse power protection function can be enabled or disabled by the following command. The choice can be either YES or NO.

WRITE PROTECT RP ENABLED <Choice>

The trip level of the reverse power function is expressed in one of three different ways. The mode of operation depends on the previously explained load calculation parameter and the mode set by the function mode parameter (single phase or sum).

1. According to the generators maximum active current in a single phase. The 100 % reference is the generators maximum current in one phase (GENMAXCUR).

2. According to the generators maximum active load on one phase. The 100 % reference is the primary phase-neutral voltage multiplied by the generators maximum current

$$\frac{PRIMVOLT}{\sqrt{3}} \cdot GENMAXCUR \text{ in one phase.}$$

3. According to the generator sum load (as indicated on the kW meter). The 100 % reference is the sum of the nominal phase-neutral voltages multiplied by the generators maximum current.

$$3 \cdot \frac{PRIMVOLT}{\sqrt{3}} \cdot GENMAXCUR$$

The level is set by the following command. The level can be set between 0 and -20 %. Resolution is 1 %.

WRITE PROTECT RP LEVEL <Level>

The delay is expressed in seconds and can be set between 2.0 and 20.0 s. Resolution is 100 ms.

WRITE PROTECT RP DELAY <Delay>

The pre-alarm delay is expressed in seconds and can be set between 2.0 and 20.0 s. Resolution is 100 ms.

WRITE PROTECT RP PDELAY <Delay>

The mode (single phase or sum) can be set by the following command. The choice can be PHASE or SUM.

WRITE PROTECT RP MODE <Choice>

7.4.5 Excitation Loss

The excitation loss protection function can be enabled or disabled by the following command. The choice can be either YES or NO.

WRITE PROTECT EL ENABLED <Choice>

The trip level of the excitation loss function is expressed in one of three different ways. The mode of operation depends on the previously explained load calculation parameter and the mode set by the function mode parameter (single phase or sum).

1. According to the generators maximum active current in a single phase. The 100 % reference is the generators maximum current in one phase (GENMAXCUR).

2. According to the generators maximum active load on one phase. The 100 % reference is the primary phase-neutral voltage multiplied by the generators maximum current

   $\frac{PRIMVOLT}{\sqrt{3}} \cdot GENMAXCUR$ in one phase.

3. According to the generator sum load (as indicated on the kVAr meter). The 100 % reference is the sum of the nominal phase-neutral voltages multiplied by the generators maximum current.

$$3 \cdot \frac{PRIMVOLT}{\sqrt{3}} \cdot GENMAXCUR$$

The level is set by the following command. The level can be set between 0 and -150 %. Resolution is 1 %.

WRITE PROTECT EL LEVEL <Level>

The delay is expressed in seconds and can be set between 2.0 and 20.0 s. Resolution is 100 ms.

WRITE PROTECT EL DELAY <Delay>

The pre-alarm delay is expressed in seconds and can be set between 2.0 and 20.0 s. Resolution is 100 ms.

WRITE PROTECT EL PDELAY <Delay>

The mode (single phase or sum) can be set by the following command. The choice can be PHASE or SUM.

WRITE PROTECT EL MODE <Choice>

7.4.6 Voltage Establishment

The voltage establishment protection function can be enabled or disabled by the following command. The choice can be either YES or NO.

WRITE PROTECT VE ENABLED <Choice>

The lower level of the voltage establishment function is expressed as a percentage according to the primary voltage (PRIMVOLT). The level is set by the following command. The level can be set between 50 and 100 %. Resolution is 1%.

WRITE PROTECT VE LOWLEVEL <Level>

The upper level of the voltage establishment function is expressed as a percentage according to the primary voltage (PRIMVOLT). The level is set by the following command. The level can be set between 50 and 100 %. Resolution is 1%.

WRITE PROTECT VE UPLEVEL <Level>

The delay is expressed in seconds and can be set between 100 and 150 s. Resolution is 1 s.

WRITE PROTECT VE DELAY <Delay>

The pre-alarm delay is expressed in seconds and can be set between 100 and 150 s. Resolution is 1 s.

WRITE PROTECT VE PDELAY <Delay>

7.4.7 Frequency Establishment

The frequency establishment protection can be enabled or disabled. This is done by the following command. The choice can be set to either *YES* or *NO*.

WRITE PROTECT FE ENABLED <Choice>

The lower trip level is expressed in percent without decimals. The trip level refers to the nominal phase-phase voltage. The lower trip level is set by the following command. Resolution is 1 %.

WRITE PROTECT FE LOWLEVEL <Level>

The upper trip level is expressed in percent without decimals. The trip level refers to the nominal voltage. The upper trip level is set by the following command. Resolution is 1 %.

WRITE PROTECT FE UPLEVEL <Level>

The lower delay is expressed in seconds with one decimal. The delay is set by the following command. Resolution is 0.1 s.

WRITE PROTECT FE LOWDELAY <Duration>

The upper delay is expressed in seconds with one decimal. The delay is set by the following command. Resolution is 0.1 s.

WRITE PROTECT FE UPDELAY <Duration>

7.5 Load Shedding

The load shedding functions (trip of non-essential loads) can be configured to trip on either low frequency or high load (measured as active current or load).

7.5.1 Non-Essential 1

The non-essential 1 load trip function can be enabled or disabled by the following command. The choice can be either YES or NO.

WRITE LOADTRIP NE1 ENABLED <Choice>

The function can be configured to trip on either low frequency (under frequency), on high load (measured as active current or load) or on high current. The selection is done by the following command. The choice can be FREQ, LOAD or CUR.

WRITE LOADTRIP NE1 PARAM <Choice>

The trip level of the NE1 trip function is expressed in one of three different ways. The mode of operation depends on setting of the parameter choice (described above), or the previously explained load calculation parameter and the mode set by the function mode parameter (single phase or sum).

1. According to the generators nominal frequency. The 100 % reference is the rated frequency (RATEDFREQ).

2. According to the generators maximum active current in a single phase. The 100 % reference is the generators maximum current in one phase (GENMAXCUR).

3. According to the generators maximum active load on one phase. The 100 % reference is the primary phase-neutral voltage multiplied by the generators maximum current

$$\frac{PRIMVOLT}{\sqrt{3}} \cdot GENMAXCUR \text{ in one phase.}$$

4. According to the generator sum load (as indicated on the kVAr meter). The 100 % reference is the sum of the nominal phase-neutral voltages multiplied by the generators maximum current.

$$3 \cdot \frac{PRIMVOLT}{\sqrt{3}} \cdot GENMAXCUR$$

The level is set by the following command. The level can be set between 20 and 150 %. Resolution is 1 %.

WRITE LOADTRIP NE1 LEVEL <Level>

The NE1 function will automatically reset by hysteresis, provided that the NE1 relay has been configured for non-latching operation. The hysteresis has no effect when the NE1 relay is configured for latching operation. The hysteresis is set by the following command. The level can be set between 1 and 100 %. The reference is the trip point defined by the level.

WRITE LOADTRIP NE1 HYST <Level>

The delay is expressed in seconds and can be set between 1.0 and 60.0 s. Resolution is 100 ms.

WRITE LOADTRIP NE1 DELAY <Delay>

The mode parameter will only be in effect when the trip parameter is load. The mode (single phase or sum) can be set by the following command. The choice can be PHASE or SUM.

WRITE LOADTRIP NE1 MODE <Choice>

7.5.2 Non-Essential 2

The non-essential 2 load trip function can be enabled or disabled by the following command. The choice can be either YES or NO.

WRITE LOADTRIP NE2 ENABLED <Choice>

The function can be configured to trip on either low frequency (under frequency), on high load (measured as active current or load) or on high current. The selection is done by the following command. The choice can be FREQ, LOAD or CUR.

WRITE LOADTRIP NE2 PARAM <Choice>

The trip level of the NE2 trip function is expressed in one of three different ways. The mode of operation depends on setting of the parameter choice (described above), or the previously explained load calculation parameter and the mode set by the function mode parameter (single phase or sum).

5. According to the generators nominal frequency. The 100 % reference is the rated frequency (RATEDFREQ).

6. According to the generators maximum active current in a single phase. The 100 % reference is the generators maximum current in one phase (GENMAXCUR).

7. According to the generators maximum active load on one phase. The 100 % reference is the primary phase-neutral voltage multiplied by the generators maximum current

   $$\frac{PRIMVOLT}{\sqrt{3}} \cdot GENMAXCUR \text{ in one phase.}$$

8. According to the generator sum load (as indicated on the kVAr meter). The 100 % reference is the sum of the nominal phase-neutral voltages multiplied by the generators maximum current.

   $$3 \cdot \frac{PRIMVOLT}{\sqrt{3}} \cdot GENMAXCUR$$

The level is set by the following command. The level can be set between 20 and 150 %. Resolution is 1 %.

WRITE LOADTRIP NE2 LEVEL <Level>

The NE2 function will automatically reset by hysteresis, provided that the NE1 relay has been configured for non-latching operation. The hysteresis has no effect when the NE1 relay is configured for latching operation. The hysteresis is set by the following command. The level can be set between 1 and 100 %. The reference is the trip point defined by the level.

WRITE LOADTRIP NE2 HYST <Level>

The delay is expressed in seconds and can be set between 1.0 and 60.0 s. Resolution is 100 ms.

WRITE LOADTRIP NE2 DELAY <Delay>

The mode parameter will only be in effect when the trip parameter is load. The mode (single phase or sum) can be set by the following command. The choice can be PHASE or SUM.

WRITE LOADTRIP NE2 MODE <Choice>

7.6 I/O and Relays

The properties of the inputs, outputs and relays can be configured by the following parameters.

7.6.1 Alarm Relay Function

The alarm relay can be configured to signal either system alarm or system and protection alarms.

The relay function is set by the following command. The choice can be either SYS or SYSPROT.

WRITE IORELAYS ALARMRELAYFUNC <Choice>

7.6.2 C/B Trip Relay

The C/B Trip relay can be configured for normally de-energized or normally energized operation. The default setting is normally energized operation, as this setting would cause a C/B trip if both the primary and back-up supply is lost.

The relay function is set by the following command. The choice can be either ND or NE.

WRITE IORELAYS CBTRIPRELAY CONTACT <Choice>

7.6.3 NE1 Trip Relay

The NE1 Trip relay can be configured for normally de-energized or normally energized operation. The default setting is normally de-energized operation. The NE1 Trip relay can either latch (requiring manual reset) or it can auto-reset by delay.

The relay function is set by the following command. The choice can be either ND or NE.

WRITE IORELAYS NE1TRIP CONTACT <Choice>

The latch function is set as follows. Choice and be YES or NO (default is YES).

WRITE IORELAYS NE1TRIP LATCH <Choice>

7.6.4 NE2 Trip Relay

The NE2 Trip relay can be configured for normally de-energized or normally energized operation. The default setting is normally de-energized operation. The NE2 Trip relay can either latch (requiring manual reset) or it can auto-reset by delay.

The relay function is set by the following command. The choice can be either ND or NE.

WRITE IORELAYS NE2TRIP CONTACT <Choice>

The latch function is set as follows. Choice and be YES or NO (default is YES).

WRITE IORELAYS NE2TRIP LATCH <Choice>

7.6.5 Unload trip

In case separate outputs for protection trip an unload trip are required, it is possible to redirect the unload trip to terminal 2 of the auxiliary I/O. The choice can be either CBTRIP or AUXIO2 (default is CBTRIP, meaning both functions are performed through CB trip relay in default configuration):

WRITE IORELAYS UNLOADTRIP <Choice>

7.6.6 Auxiliary outputs

S6000 contains 3 auxiliary outputs. The auxiliary outputs can be programmed to activate for alarms, status messages or unload trip. It is only possible to assign one function to an auxiliary output.

In case the output is configured to activate for an alarm, the output will be activated as soon as the alarm appears and will be deactivated again after reset of the alarm.

In case the output is programmed for a status indication, it will be activated as long as the status is true. It will de-activate as soon as the status changes.

In case an output is programmed as an unload trip the output will activate as soon as the generator load is below the UNLOAD TRIP LEVEL provided there is an unload command present at the UNLOAD input of S6100 or through the S6610 PM Module.

The command for assigning a function to auxiliary output 1 is:

WRITE IORELAYS AUX1OUT <Choice>

The command for assigning a function to auxiliary output 2 is:

WRITE IORELAYS AUX2OUT <Choice>

The command for assigning a function to auxiliary output 3 is:

WRITE IORELAYS AUX3OUT <Choice>

The CHOICE can be as follows: VEUPPER, VELOWER, FEUPPER, FEUNDER, VOLTPHASEOK, UNLOADTRIP:

VEUPPER over-voltage

VELOWER under-voltage

FEUPPER over-frequency

FEUNDER under-frequency

VOLTPHASEOK Indication that the voltage is within the VOLTAGE OK window and that there is phase accordance between generator and bus bar voltage

UNLOADTRIP The output activates as soon as an UNLOAD command is active and the generator load passes below UNLOAD TRIP LEVEL.

7.7 Open collector protection outputs

The open collector protection outputs are placed on the C/B TRIP CAUSE & GND connector of the S6000 Module. These outputs can be used for external indication of alarms. On earlier firmware versions (before 071112) these outputs were fixed (terminal 1 = SC, terminal 2 = OC, terminal 3 = OL, terminal 4 = RP, terminal 5 = EL, terminal 6 = VE). From FW 071112 the functions of these outputs can be configured. It is possible to assign more than one function to one output, thus it is possible to configure common alarms.

Each function has one command line. The function can be set by the command line followed by a choice. The choice can be OFF for deactivation of this function or the output number: OFF, OC1, OC2, OC3, OC4, OC5, OC6.

WRITE OCPROTOUT SC *[OFF, OC1, OC2, OC3, OC4, OC5, OC6](OC1)*

WRITE OCPROTOUT OC *[OFF, OC1, OC2, OC3, OC4, OC5, OC6] (OC2)*

WRITE OCPROTOUT OL *[OFF, OC1, OC2, OC3, OC4, OC5, OC6] (OC3)*

WRITE OCPROTOUT RP *[OFF, OC1, OC2, OC3, OC4, OC5, OC6] (OC4)*

WRITE OCPROTOUT EL *[OFF, OC1, OC2, OC3, OC4, OC5, OC6] (OC5)*

WRITE OCPROTOUT VEUPPER *[OFF, OC1, OC2, OC3, OC4, OC5, OC6(OC6)]*

WRITE OCPROTOUT VELOWER *[OFF, OC1, OC2, OC3, OC4, OC5, OC6] (OC6)*

WRITE OCPROTOUT FEUPPER *[OFF, OC1, OC2, OC3, OC4, OC5, OC6] (OC6)*

WRITE OCPROTOUT FELOWER *[OFF, OC1, OC2, OC3, OC4, OC5, OC6] (OC6)*

WRITE OCPROTOUT BUSVEUPPER *[OFF, OC1, OC2, OC3, OC4, OC5, OC6] (OFF)*

WRITE OCPROTOUT BUSVELOWER *[OFF, OC1, OC2, OC3, OC4, OC5, OC6] (OFF)*

WRITE OCPROTOUT BUSFEUPPER *[OFF, OC1, OC2, OC3, OC4, OC5, OC6] (OFF)*

WRITE OCPROTOUT BUSFELOWER *[OFF, OC1, OC2, OC3, OC4, OC5, OC6] (OFF)*

WRITE OCPROTOUT BUSFD *[OFF, OC1, OC2, OC3, OC4, OC5, OC6] (OFF)*

7.8 Analogue Outputs

The analogue outputs are configured with the following parameters.

7.8.1 Analogue Output 1

The first parameter to set is the “indicated” parameters (among all the available measured and calculated parameters).

The indicated parameter is set by the following command. The choice can be any one of the following parameters: U12, U23, U31, U1N, U2N, U3N, I1, I2, I3, IA1, IA2, IA3, P1, P2, P3, P, IR1, IR2, IR3, Q1, Q2, Q3, Q, PF1, PF2, PF3, PF, VA1, VA2, VA3, VA, F. Default is P.

WRITE ANAOUT OUT1 SRC <Choice>

The output signal is set by the following command. The choice can be either voltage or current (VOLT or CUR).

WRITE ANAOUT OUT1 SIGNAL <Choice>

The next two commands scale the chosen parameter. Default is -10 and 100% respectivly.

WRITE ANAOUT OUT1 SRCMIN <value>

WRITE ANAOUT OUT1 SRCMAX <value>

Finally, the output signal must be scaled. This can be done for either voltage or current, depending on the choice made for the signal parameter. Default settings are -1 to 10 VDC and 4 to 20 mA.

WRITE ANAOUT OUT1 VOLTMIN <value>

WRITE ANAOUT OUT1 VOLTMAX <value>

Likewise for the current output.

WRITE ANAOUT OUT1 CURMIN <value>

WRITE ANAOUT OUT1 CURMAX <value>

7.8.2 Analogue Output 2

The first parameter to set is the “indicated” parameters (among all the available measured and calculated parameters).

The indicated parameter is set by the following command. The choice can be any one of the following parameters: U12, U23, U31, U1N, U2N, U3N, I1, I2, I3, IA1, IA2, IA3, P1, P2, P3, P, IR1, IR2, IR3, Q1, Q2, Q3, Q, PF1, PF2, PF3, PF, VA1, VA2, VA3, VA, F. Default is Q.

WRITE ANAOUT OUT2 SRC <Choice>

The output signal is set by the following command. The choice can be either voltage or current (VOLT or CUR).

WRITE ANAOUT OUT2 SIGNAL <Choice>

The next two commands scale the chosen parameter. Default is -10 and 100% respectivly.

WRITE ANAOUT OUT2 SRCMIN <value>

WRITE ANAOUT OUT2 SRCMAX <value>

Finally, the output signal must be scaled. This can be done for either voltage or current, depending on the choice made for the signal parameter. Default settings are -1 to 10 VDC and 4 to 20 mA.

WRITE ANAOUT OUT2 VOLTMIN <value>

WRITE ANAOUT OUT2 VOLTMAX <value>

Likewise for the current output.

WRITE ANAOUT OUT2 CURMIN <value>

WRITE ANAOUT OUT2 CURMAX <value>

7.8.3 Analogue Output 3

The first parameter to set is the “indicated” parameters (among all the available measured and calculated parameters).

The indicated parameter is set by the following command. The choice can be any one of the following parameters: U12, U23, U31, U1N, U2N, U3N, I1, I2, I3, IA1, IA2, IA3, P1, P2, P3, P, IR1, IR2, IR3, Q1, Q2, Q3, Q, PF1, PF2, PF3, PF, VA1, VA2, VA3, VA, F. Default is PF.

WRITE ANAOUT OUT3 SRC <Choice>

The output signal is set by the following command. The choice can be either voltage or current (VOLT or CUR).

WRITE ANAOUT OUT3 SIGNAL <Choice>

The next two commands scale the chosen parameter. Default is 0 and 100% respectivly.

WRITE ANAOUT OUT3 SRCMIN <value>

WRITE ANAOUT OUT3 SRCMAX <value>

Finally, the output signal must be scaled. This can be done for either voltage or current, depending on the choice made for the signal parameter. Default settings are 0 to 10 VDC and 4 to 20 mA.

WRITE ANAOUT OUT3 VOLTMIN <value>

WRITE ANAOUT OUT3 VOLTMAX <value>

Likewise for the current output.

WRITE ANAOUT OUT3 CURMIN <value>

WRITE ANAOUT OUT3 CURMAX <value>

7.9 RS485

The RS485 communication interface can be configured with regard to MODBUS slave address, baud rate, data bit, parity and stop bits. It is important to ensure that the address is unique on the bus and that the remaining parameters are set according to specifications.

The MODBUS slave address is set by the following command.

WRITE RS485 ADDRESS <Addr>

The data transmission rate is defined by the baud rate, which is set as follows.

WRITE RS485 BAUDRATE <Baudrate>

The parity can be set by the following command.

WRITE RS485 PARITY <Parity>

The number of data bits is set as follows.

WRITE RS485 DATABITS <Databits>

The number of stop bits is set as follows.

WRITE RS485 STOPBITS <Stopbits>

In case the data from the MODBUS master is send irregular (compared to MODBUS specification) it is possible to adjust a delay for detection of the end of the MODBUS frame send by the master. Following command is used for that:

WRITE RS485 TXDELAY [0-2552] (0)

The range is between 0 and 2552ms. Default is 0ms.

In case the frames send by the MODBUS master comply with the MODBUS specifications it is not necessary to change this parameter (it can remain in default setting).

7.10 Restoring to factory default configuration

The factory default configuration can be restored at any time by issuing the command:

WRITE SYS SETUPDEFAULT YES

The default configuration is then restored after the power to the module has been turned off and on.

8 Specifications

Primary Supply:	+24 V DC (-30 % / +30 %) Isolated, 500 mA
Backup Supply:	+24 V DC (-30 % / +30 %) Isolated, 500 mA
Gen. phase-phase voltage (GPPV):	63.0 to 690.0 V AC (-2 % / +2 %) three phased
Gen. indicated voltage (GIV):	63 to 32 kV AC
Gen. phase-neutral voltage (GPNV):	GPPV / √3 (measured with neutral connection, estimated without)
CT secondary current (CTSC):	1 A or 5 A (consumption 25 mW or 125 mW) three phased
Gen. rated frequency (GRF):	40.0 to 500.0 Hz
Gen. maximum current (GMC)	0.5 to 3000.0 A / 500 to 30000 A
Protection functions	
Short Circuit	
On/Off Control:	By Configuration
Characteristic:	Definite time
Modes:	Current, largest of three phases (I_1, I_2 or I_3)
Trip level:	+100 to +400 % of GMC
Pre-alarm:	100 to 1000 ms on OC output
Delay:	100 to 1000 ms
Relay:	C/B Trip, with feedback from C/B State input
Output:	Dedicated open collector output (200 mA)
Indication:	Red SC LED on front folio (shows pick-up and trip)
Reset	By common C/B reset input or UI Reset button
Over Current	
On/Off Control:	By Configuration
Characteristic:	Definite time
Modes:	Current, highest of three phases (I_1, I_2 or I_3)
Trip level:	+50 to +140 % of GMC
Pre-alarm:	0.1 to 30.0 s on OC output
Delay:	0.1 to 30.0 s
Relay:	C/B Trip, with feedback from C/B State input
Output:	Dedicated open collector output (200 mA)
Indication:	Red OC LED on front folio (shows pick-up and trip)
Reset	By common C/B reset input or UI Reset button
Over Load	
On/Off Control:	By Configuration
Characteristic:	Definite time
Modes (without neutral):	Active current, highest of three phases ($I_{Active1}$, $I_{Active2}$ or $I_{Active3}$)
Modes (with neutral):	Active current, highest of three phases ($I_{Active1}$, $I_{Active2}$ or $I_{Active3}$) Active power, highest of three phases (P_1, P_2 or P_3) Sum active power (P)
Trip level (active current):	+15 to +150 % of GMC
Trip level (active power):	+15 to +150 % of GIV x GMC
Pre-alarm:	2.0 to 20.0 s on OC output
Delay:	2.0 to 20.0 s
Relay:	C/B Trip, with feedback from C/B State input
Output:	Dedicated open collector output (200 mA)
Indication:	Red OL LED on front folio (shows pick-up and trip)
Reset	By common C/B reset input or UI Reset button
Reverse Power	
On/Off Control:	By Configuration
Characteristic:	Definite time
Modes (without neutral):	Active current, lowest of three phases ($I_{Active1}$, $I_{Active2}$ or $I_{Active3}$)
Modes (with neutral):	Active current, lowest of three phases ($I_{Active1}$, $I_{Active2}$ or $I_{Active3}$) Active power, lowest of three phases (P_1, P_2 or P_3) Sum active power (P)
Trip level (active current):	0 to -20 % of GMC
Trip level (active power):	0 to -20 % of GIV x GMC
Pre-alarm:	2.0 to 20.0 s on OC output

Delay:	2.0 to 20.0 s
Relay:	C/B Trip, with feedback from C/B State input
Output:	Dedicated open collector output (200 mA)
Indication:	Red OL LED on front folio (shows pick-up and trip)
Reset	By common C/B reset input or UI Reset button

Execitation Loss

On/Off Control:	By Configuration
Characteristic:	Definite time
Modes (without neutral):	Reactive current, lowest of three phases ($I_{Reactive1}$, $I_{Reactive2}$ or $I_{Reactive3}$)
Modes (with neutral):	Reactive current, lowest of three phases ($I_{Reactive1}$, $I_{Reactive2}$ or $I_{Reactive3}$) Reactive power, lowest of three phases (Q_1, Q_2 or Q_3) Sum reactive power (Q)
Trip level (react. current):	0 to +150 % of GMC
Trip level (react. power):	0 to +150 % of GIV x GMC
Pre-alarm:	2.0 to 20.0 s on OC output
Delay	2.0 to 20.0 s
Relay:	C/B Trip, with feedback from C/B State input
Output:	Dedicated open collector output (200 mA)
Indication:	Red EL LED on front folio (shows pick-up and trip)
Reset	By common C/B reset input or UI Reset button

Voltage Establishment

On/Off Control:	By Configuration
Characteristic:	Definite time
Lower trip level:	+50 to +100 % of GIV
Upper trip level:	+100 to 150 % of GIV
Pre-alarm:	1.0 to 30.0 s on OC output
Delay:	1.0 to 30.0 s, default 2.0 s
Relay:	C/B Trip, with feedback from C/B State input
Output:	Dedicated open collector output (200 mA)
Indication:	Red VE LED on front folio (shows pick-up and trip)
Reset	By common C/B reset input or UI Reset button

Load shedding functions

Non essential trip 1

On/Off Control:	By Configuration
Characteristic:	Definite time
Modes (without neutral):	Frequency Active current, highest of three phases ($I_{Active1}$, $I_{Active2}$ or $I_{Active3}$) Current, highest of three phases (I_1, I_2 or I_3)
Modes (with neutral):	Frequency Active current, highest of three phases ($I_{Active1}$, $I_{Active2}$ or $I_{Active3}$) Active power, highest of three phases (P_1, P_2 or P_3) Sum active power (P) Current, highest of three phases (I_1, I_2 or I_3)
Trip level (frequency):	+20 to +150 % of GRF
Trip level (active current):	+20 to +150 % of GMC
Trip level (active power):	+20 to +150 % of GIV x GMC
Trip Level (current)	+20 to +150% of GMC
Hysteresis (non-latch):	1 to 100 %
Delay:	1.0 to 60.0 s
Relay:	NE1 Trip, latching or non-latching (hysteresis reset)
Output:	Dedicated open collector output (200 mA)
Indication:	Yellow NE1 LED on front folio (shows pick-up and trip)
Reset	By common NE reset input

Non essential trip 2

On/Off Control:	By Configuration
Characteristic:	Definite time
Modes (without neutral):	Frequency

		Active current, highest of three phases ($I_{Active1}$, $I_{Active2}$ or $I_{Active3}$)
		Current, highest of three phases (I_1, I_2 or I_3)
	Modes (with neutral):	Frequency
		Active current, highest of three phases ($I_{Active1}$, $I_{Active2}$ or $I_{Active3}$)
		Active power, highest of three phases (P_1, P_2 or P_3)
		Sum active power (P)
		Current, highest of three phases (I_1, I_2 or I_3)
	Trip level (frequency):	+20 to +150 % of GRF
	Trip level (active current):	+20 to +150 % of GMC
	Trip level (active power):	+20 to +150 % of GIV x GMC
	Trip Level (current)	+20 to +150% of GMC
	Hysteresis (non-latch):	1 to 100 %
	Delay:	1.0 to 60.0 s
	Relay:	NE2 Trip, latching or non-latching (hysteresis reset)
	Output:	Dedicated open collector output (200 mA)
	Indication:	Yellow NE2 LED on front folio (shows pick-up and trip)
	Reset	By common NE reset input

C/B Trip Relay:

Relay response time:	20 ms (worst case)
Contact set(s)	1
Contact rating:	AC: 8 A, 250 V AC, DC: 8 A, 35 V DC
Function:	Normally energized (Default) or normally de-energized

NE1 Trip Relay:

Relay response time:	20 ms (worst case)
Contact set(s)	2
Contact rating:	AC: 8 A, 250 V AC, DC: 8 A, 35 V DC
Function:	Normally de-energized (Default) or normally energized

NE2 Trip Relay:

Relay response time:	20 ms (worst case)
Contact set(s)	2
Contact rating:	AC: 8 A, 250 V AC, DC: 8 A, 35 V DC
Function:	Normally de-energized (Default) or normally energized

Alarm Relay

Relay response time:	20 ms (worst case)
Contact set(s)	2
Contact rating:	AC: 8 A, 250 V AC, DC: 8 A, 35 V DC
Function:	Normally energized

Voltage OK

Level:	0 to 20 % of GPPV, default 10 %
Indication:	Steady light within limits

Phase OK indication

Indication:	Steady light when all three phases are live and sequence is correct

Analogue Outputs

Output 1

Source parameter:	U_{12}, U_{23}, U_{31}, U_{1N}, U_{2N}, U_{3N}, I_1, I_2, I_3, $I_{Active1}$, $I_{Active2}$, $I_{Active3}$, P_1, P_2, P_3, P, $I_{Reactive1}$, $I_{Reactive2}$, $I_{Reactive3}$, Q_1, Q_2, Q_3, Q, PF_1, PF_2, PF_3, PF, VA_1, VA_2, VA_3, VA or f
	-1000.0 to +1000.0 %
Signal:	Voltage (±10.000 to ±10.000 V DC) isolated
	Current (0.000 to +24.000 mA) isolated

Output 2

Source parameter:	U_{12}, U_{23}, U_{31}, U_{1N}, U_{2N}, U_{3N}, I_1, I_2, I_3, $I_{Active1}$, $I_{Active2}$, $I_{Active3}$, P_1, P_2, P_3, P, $I_{Reactive1}$, $I_{Reactive2}$, $I_{Reactive3}$, Q_1, Q_2, Q_3, Q, PF_1, PF_2, PF_3, PF, VA_1, VA_2, VA_3, VA or f
	-1000.0 to +1000.0 %
Signal:	Voltage (±10.000 to ±10.000 V DC) isolated
	Current (0.000 to +24.000 mA) isolated

Output 3

Source parameter:	U_{12}, U_{23}, U_{31}, U_{1N}, U_{2N}, U_{3N}, I_1, I_2, I_3, $I_{Active1}$, $I_{Active2}$, $I_{Active3}$, P_1, P_2, P_3, P, $I_{Reactive1}$, $I_{Reactive2}$, $I_{Reactive3}$, Q_1, Q_2, Q_3, Q, PF_1, PF_2, PF_3, PF, VA_1, VA_2, VA_3, VA or f
	-1000.0 to +1000.0 %
Signal:	Voltage (±10.000 to ±10.000 V DC) isolated
	Current (0.000 to +24.000 mA) isolated
CAN Bus	
Connection	Screw terminals, 2-wire with COM (limp back function)
Protocol:	CANOpen derivative
RS232	
Connection:	Customized plug, 4-wire (non-isolated)
Function:	Configuration, Debugging or firmware update
Protocol:	ANSI terminal
Baud rate:	1200, 2400, 4800, 9600 or 19200 baud
Parity:	None, even or odd
Data bits:	7 or 8
Stop bits:	1 or 2
RS485	
Connection:	Screw terminals, 2-wire (isolated)
Protocol:	MODBUS-RTU
Address range	1 to 254
Baud rate:	1200, 2400, 4800, 9600 or 19200 baud
Parity:	None, even or odd
Data bits:	7 or 8
Stop bits:	1 or 2
EMC / EMI tests:	EN 50081-2:1993 (Generic: Residential, commercial & light industry)
	EN 50263:1999 (Product: Measuring relays and protection equipment)
Marine tests:	EN 60945:1997 (Marine: Navigation and radio comm. equipment and systems)
	IACS E10:1997 (IACS unified environmental test specification)
Connections:	Plug-in screw terminals (spring terminals available as option)
Dimensions:	145 x 190 x 64.5 mm (H x W x D)
Weight:	1150 g
Fixation:	Screw mounting (4 pcs. 4.2 x 12 mm)

The specifications are subject to change without notice.